REMARKS

This responds to the Office Action dated March 11, 2003, applicant thanks the Examiner for withdrawing the previously made oral restriction requirement. Applicant also thanks the Examiner for allowing the submission of this subsequent response. Applicant further respectfully requests reconsideration of the application in view of the above amendments and the following remarks.

Claims 19-29 are pending in this application. Original claims 1-7 and new claims 8-18 submitted in the previous response have been cancelled. New claims 19-29 have been added to define the present invention in a more accurate fashion. Among these new claims, claims 19 and 29 are independent. Claims 20-28 depend from claim 19. Independent claims 19 and 29 recite method and apparatus for generating a vertical magnetic field in an air gap for ferrohydrostatic separation by using a C dipole, an open dipole (O dipole), or split pair electromagnet or permanent magnet. Claims 20-28 further define the invention. Support for these claims can be found, for example, from Figures 2 to 6, and their corresponding descriptions at page 6, line 5 to page 8, line 13 of the specification. No new matter has been added.

"Brief Description of Drawings" has been inserted

In section 1 of the Office Action, the disclosure was objected to as lacking a section entitled "Brief Description of Drawings". Accordingly, applicant had, in the previous response, inserted the section and this objection is therefore believed moot because of the insertion.

Claim objections are moot due to the cancellation of original claims

In section 2 of the Office Action, original claims 1-7 were objected to as being in improper form. In response to this objection, applicant has canceled original claims 1-7 and added new claims 19-29 to define the invention more accurately. These claim objections are therefore moot due to the claim cancellations.

Figure 1 has been designated as "prior art"

In section 3 of the Office Action, Figure 1 was objected to as not being designated as prior art. Accordingly, applicant had, in the previous response, inserted a "Prior Art" legend into Figure 1 to designate it as a figure illustrating prior art. This objection is therefore believed moot in view of applicant's amendment of Figure 1.

35 U.S.C § 112 rejections were moot

In section 4 of the Office Action, claims 1-5 and 7 were rejected under 35 U.S.C. § 112 as being indefinite. These rejection are also moot due to the cancellation of claims 1-7. It is further respectfully submitted that new claims 19-29 satisfy section 112 since, as explained above, these claims particularly point out the invention.

New claims 19-29 distinguish patentably from the references cited in 35 U.S.C § 102 (b) rejections

In section 5 of the Office Action, claims 1, 2, and 4-7 were rejected under 35 U.S.C. § 102 (b) as being anticipated by a number of references. These references are U.S. patent #3,898,156 to Kaiser et al. ("Kaiser"), U.S. patent #4,052,297 to Mir ('Mir"), U.S. patent #4,062,765 to Fay et al. ("Fay"), and U.S. patent 3,788,465 to Reimers et al. ("Reimers").

These rejections are moot due to the cancellation of claims 1-7. It is further respectively submitted that pending independent claims 19 and 29 distinguish patentably from these references for at least the following reasons.

Kaiser discloses a magnet comprising a yoke with hyperbolic pole pieces attached to the poles of the yoke in a symmetric fashion and an adjustable mirror plate separated from the poles for tuning the magnetic field between the poles. See, e.g., Figure 2 and col. 4, lns. 17--35 and col. 5 ln. 22--col. 6, ln. 10 of the specification. It is respectfully submitted that persons skilled in the art will immediately recognize that the electromagnet formed by yoke 16 and coils 26, 28 along with poles 12, 14, as disclosed in Kaiser, is a U-dipole electromagnet, <u>not</u> a C-dipole electromagnet as stated by the Office Action. The difference between a U-dipole and a C-dipole electromagnet can be explained with reference to the attached drawing labeled as "Exhibit A".

In the conventional ferrohydrostatic (FHS) as described by Kaiser, the U-dipole magnet has an air gap in which the magnetic field is horizontally oriented while the field gradient, which is essential for the generation of FHS, is vertically oriented. Typically the vertical orientation of the field gradient is achieved by specifically shaping the tips of the pole pieces of the magnet.

One of the drawbacks of the Kaiser system is that it is very difficult to scale-up the magnitude of the field gradient in order to treat large throughputs of material. As the throughput is determined by the width of the air gap between the pole pieces, the gap has to be increased for larger throughputs at substantial expense. This is further explained as follows.

According to Ampere's circuit law, an increase in the width of the air gap between the pole pieces of an electromagnet necessitates a corresponding increase in the magnetomotive force or the number of wire turns in the coil of the magnet. This is stated in the equation:

$$BL = \mu_0 NI$$

where B is the magnetic flux density in the air gap, L is the width of the air gap, N is the number of turns of wire in the coil of the magnet, I is the electrical current through the coil and μ_0 is the magnetic permeability of a vacuum.

Referring now to the C-dipole magnet shown in Exhibit A, notice that the magnetic field and the field gradient are both vertical and parallel. In order to scale up the magnitude , the magnet can simply be made longer, i.e. in a direction into the plane of the paper. There is therefore no need to increase the width of the air gap or the number of wire turns.

Furthermore, in a C-dipole the field gradient is generated by appropriate design of the magnetizing coils on the upper and lower legs of the C-dipole. In contrast to this, the field gradient in a U-dipole is generated by having specially shaped tips on the pole pieces. The advantage of the C-dipole is that a far more accurate field gradient is obtained compared to the U-dipole where the accuracy of the field gradient is impaired by non-linear magnetization resulting from the manner in which the tips were shaped. To further distinguish the invention from Kaiser, it is further respectfully submitted that throughputs of up to 100t/h can be obtained with a C-dipole of in one embodiment of the invention, whereas the FHS taught by Laiser can only has a possible throughput of 1t/h.

Mir discloses a method and system for adjusting the height of the ferrofluid column in a ferrofluid separator by controlling the location of the access openings into the column of ferrofluid so that the opening is on a pre-determined air-ferrofluid interface to support a

specific height of a ferrofluid column. See, e.g., Figure 3 and col. 3, ln. 25--col. 4, ln. 38 of the specification. Mir, like Kaiser, only discloses a U-dipole electromagnet (see Figure 2) generating the magnetic field for the FHS system.

Fray discloses an apparatus for separating materials of different densities comprising magnets for generating a magnetic field to control the density of the ferrofluid in order to separate materials of different density. See, e.g., Figure 1a, Figure 1b and col. 6. ln. 43--col. 7, ln. 18 of the specification. Fray also discloses using a grid of U-shaped electrical conducting segments to generate a desired magnetic field. See, e.g., Figure 3 and col. 7, lns. 19--49 of the specification. It is respectfully submitted that <u>Fray does not teach, disclose, or even suggest controlling the density of the ferrofluid to a substantially constant value</u>. Fray expressly states in, for example, col. 3, lns. 25--28 and col. 7, ln. 63--col. 8, ln. 4, that the magnetic field gradient generated by the grid system and thus the density of the magnetic fluid are not constant in the separation space.

As a result of the non-uniformity of the density of the ferrofluid, the densities of the materials to be separated must differ from one another by a substantial amount. See for instance the statement in col. 9, lns 2-4 that "... the density should differ by at least 1.0g/cm^3. More preferably, the density should differ by at least 3.0g/cm^3". This density difference is very undesirable for FHS systems since many considerably cheaper and simpler techniques existed before FHS can be used to separate particles with smaller density differences.

Furthermore, in view of the greatly varying separation conditions in the grid system, Fay requires that the feed into the system be sized to a narrow range, as explained in col. 9, lns 25--34. Fay also imposes an upper limit of 25mm on the particle size (col. 9, lns 22--24). It is respectfully submitted that these requirements are completely unrealistic in the context

of a high throughput material separation system, and compliance with such requirements would present a serious limitation for industry-scale applications.

Reimers discloses a method for separating materials of different densities comprising the steps of passing a mixture of materials having different densities through a volume of magnetic fluid and collecting fractions of the materials of different densities as they emerge from the fluid. The volume of magnetic fluid is subject to a non-uniform magnetic field so that different materials traverse the fluid in a different trajectory. See, e.g., Figure 3 and col. 6, ln 2--col. 7 ln. 19 of the specification. Reimers, like Kaiser and Mir, only teaches a U-dipole electromagnet (see Figure 2) generating the magnetic field for the FHS system.

By contrast, pending independent claim 19 expressly requires controlling the density of the ferrofluid <u>to a substantially constant value</u> by means of a vertically orientated magnetic field generated <u>by a C dipole, an open dipole (O dipole), or split pair electromagnet or permanent magnet</u>. Pending independent claim 29 expressly requires <u>a C dipole, O dipole or split pair magnet</u> adjacent the chamber for generating a magnetic field to control the apparent density of the ferrofluid <u>to a substantially constant value</u>. Accordingly, it is respectfully submitted that pending independent claims 19 and 29 distinguish patentably from Kaiser, Mir, Fray and Reimers.

Pending claims 20-28 depend from claim 19, these claims are also believed patentable for the same reason above associated with claim 19.

<u>New claims 19-29 distinguish patentably from the reference cited in the 35 U.S.C. § 103 (a) rejection</u>

In section 6 of the Office Action, claims 1, 3, 6 and 7 were rejected under 35 U.S.C. § 103 (a) as being unpatentable over U.S. patent #4,085,037 to Quets et al. ("Quets") in view of

what is well known in the art. This rejection is moot following the cancellation of claims 1-7. It is further respectfully submitted that pending claims 19-29 distinguish patentably from Quets for at least the following reasons.

Quets discloses using one or two magnets to generate magnetic fields for ferrohydrodynamic particle separation, wherein these magnets are arranged into different placements with different air gaps to cop with different material separations. See, e.g., Figure 1a--1c and col. 6, ln. 19--ln. 26 of the specification. It is apparent that Quet simply uses one or two blocks of permanent magnets to achieve a specific separation objective without paying any attention to designing the magnet to control the density of the ferrofluid <u>to a substantially constant value</u> . Furthermore, Quets's teachings provide no clue to solve the scale-up problem of the FHS system.

It is therefore respectfully submitted that pending independent claims 19 and 29 distinguish patentably from Quets since these claims expressly require <u>a C dipole, O dipole or split pair magnet</u> for generating a magnetic field to control the density of the ferrofluid <u>to a substantially constant value</u>.

Pending claims 20-28 depend from claim 19, these claims are also believed patentable for the same reason above associated with claim 19.

CONCLUSION

In light of the above, it is respectfully submitted that the present application is in condition for allowance. Favorable disposition is respectfully requested. Should the Examiner have any questions or comments concerning this submission, or any aspect of the application, the Examiner is respectfully invited to call the undersigned at the phone number listed below.

No fee other than the time extension fee is believed due at this time. Should any fees be required, please charge such fees to Pennie & Edmonds LLP Account No. 16-1150.

Respectfully submitted,

Reg. No. 51,794

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for 31,231

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